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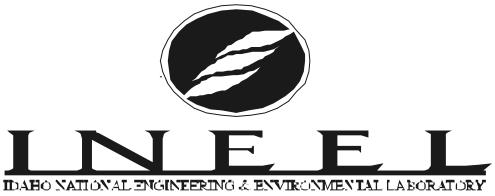

Wireless Handheld Scanners Integrated with Waste Tracking

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ABSTRACT

The US Department of Energy (DOE) Idaho National Engineering and Environmental Laboratory (INEEL) has embraced mobile wireless technology to help the disposition of hazardous and mixed radiological waste. The following paper describes one application the INEEL developed to increase the data accuracy and near-real time reporting requirements for waste management. With the continuous operational demands at the "site", it was difficult to sustain an accurate, up-to-date database required for regulatory compliance audits and reporting. Incorporating wireless mobile technology, the INEEL was able to increase the accuracy while reducing the data delay times previously encountered. Installation issues prolonged the project along with obstacles encountered with operations personnel. However, the success of this project was found in persistence and management support as well as the technology itself. Future wireless, mobile computing will continue at the INEEL for years to come based on a successful project that was able to integrate new technology to an existing waste management system with proven, increased data accuracy.

Keywords: Wireless, Mobile Computing, Waste, IEEE 802.11, Access Point, Handheld, Ethernet

1. SCENARIO

The truck just arrived at your facility with 20 containers of hazardous waste. You pick up your wireless mobile handheld scanner and scan the containers for receipt. One of those scanned containers was incorrectly placed on the truck and did not show up on your electronic shipment description. This is not a problem. You just uncheck the incorrect container on your mobile scanner, select the area within your facility to put the remaining containers, and you have now received all 19 containers at your facility automatically updating the site-wide waste tracking database system. The incorrectly shipped container remains on the truck to be sent back to its original location.

Ten minutes pass and the equipment operator informs you that the chosen location to place the containers is currently unavailable. This is not a problem. You pick up your wireless mobile scanner, select the "Update Container Location" menu, scan the containers choosing a new location, and once again all 19 containers at your facility are automatically updated to the correct location in the site-wide waste tracking database.

Sound like a fairy tale? Not at the INEEL. Here at the US Department of Energy (DOE) Idaho National Engineering and Environmental Laboratory (INEEL), we have integrated wireless and mobile computing into an existing waste tracking system. Any system user can log onto the wireless mobile handheld scanner and perform a multitude of functions while roaming the facility. Functions performed are items such as providing periodic inventories, assisting with shipments, retrieving instantaneous information for any given container, and many others. With nine INEEL separate facilities generating, shipping, storing, and disposing waste, the use of wireless technology has been an incredible boost for improving efficiency.

A couple of years ago, the above scenario seemed only like a dream that could never be realized. So many data issues needed to be addressed that some people thought they would never get corrected.

2. ISSUES

The INEEL had several issues involving waste management; some were: data entry, data quality, delays, and physical inventory. One problem before wireless mobile units came on-line were the delays and inaccuracies associated with manual data entry. It would take up to several weeks before information, recorded on hand written paper, was entered into the system. Once the data were entered, inevitably many errors were found which took the system administrator more time to correct. Accurate tracking and reporting of waste at the INEEL are a regulatory-driven requirement. The fact that data entered into the database were in some cases delayed for days and weeks meant that any database generated reports, shipments, inventories, etc., performed were always trailing the actual plant conditions. Data quality was very difficult to maintain on a real-time basis. Actual inventories, performed in the field, always proved the database to be less than 100%, indicating constant data inaccuracies. Other problems were containers with handwritten identification labels were hard to identify and other information labels were nonexistent. A more reliable method of obtaining container identification was required for accurate

inventory control. Inconsistent reporting and the inability to provide an accurate, timely, and complete site-wide inventory of waste to various customers including DOE, lead to the proposal to incorporate some type of wireless mobile scanning device.

3. PROPOSAL

Developers at the INEEL had heard about a new standard being developed by the Institute of Electrical and Electronic Engineers (IEEE) to provide a wireless ethernet. Research was performed and it was decided that some prototype equipment should be bought to determine the feasibility. Once we had received some equipment, tests performed at the INEEL indicated that the new IEEE standard was very applicable to our needs and that further development was justified. As development continued, it quickly became apparent that the use of wireless mobile computing met our criteria for a solution that would help solve our data quality issues. With the ease of installation (primarily plug and play devices) and the successful tests performed, it was decided that this new technology would provide the answers to our waste management problems.

4. SOLUTION

The solution for this proposal came in the form of a ruggedized, wireless, handheld scanning device that was able to communicate directly to our Integrated Waste Tracking System (IWTS) in conjunction with the capability to scan container bar codes. Through the use of Symbol Technologies Inc., Spectrum24® wireless, portable pen terminal (PPT) 4640, we were able to provide a solution that met all our requirements.

Spectrum24® technology incorporates the IEEE 802.11 Standard – "Standard for Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification" or Wireless Ethernet. It is a relatively new standard (1997) for communicating via a local area network over radio waves in the low GHz frequency range. Frequency Modulation (FM) is used to transmit digital data from one device to another. Spread spectrum (broad band) is one format used by this specification that spreads data over a specific frequency range (2.4 to 2.5 GHz). Frequency hopping spread spectrum is one method used to provide enhanced data reception in the presence of interfering signals such as microwave ovens and fixed frequency radio networks. In frequency hopping spread spectrum, the frequency of the carrier signal is changed (hopped) many times a second, using a predetermined pattern (hop sequence). Data rates are typically 1 and 2 million bits per second (Mbps). Higher rates are specified by the IEEE 802.11b standard using a direct sequence technique. This allows higher data rates including 11 Mbps. Symbol Technologies® uses a coding technique called Complementary Code Keying (CCK). CCK is a direct sequence spread spectrum technology that uses particular codes to represent data bits enabling receivers to filter out signals that do not use the same codes, such as interference or noise.[1] With incorporating a bar code scanner, touch screen, 16 Mb of RAM, a web browser, and wireless connectivity, the industrialized PPT 4640 was the perfect match.

It was determined early on in the development stages that a web browser (thin client) would be the best choice for the handheld platform. This allowed for software updates regardless of where the handheld devices were physically located throughout our 890 mi^2 site; in some cases as far away as 50 miles (80 km). Taking time to physically visit all mobile units dispersed throughout our site would have been a maintenance nightmare. Software changes are only made remotely to our database and web servers strategically located within the nine site facilities. With the help of Active Server Pages, we are able to serve up HTML pages to the handheld browser guaranteeing real time, up-to-date data. With the use of client side Javascript on the handheld scanner, we can perform simple functions that do not require a lot of programming experience. The use of touch screen helps the user to quickly navigate through the menu items.

Emergency response has been enhanced since a user can go to the spilled container, scan it, and determine immediately the contents and determine what emergency actions are to take place, if any. Information can be gathered about a container displaying contents, physical attributes, contacts, hazardous waste codes, comments, and many other characterization data.

5. INSTALLATION ISSUES

Installation of these wireless devices is relatively simple, given that a site survey has been performed beforehand. A site survey places a transceiver or Access Point (AP) in a certain location, then a handheld device is forced to continuously send out packets of data to and from the AP with response times displayed for each packet. This allows an engineer to determine precise coverage, location, and quantity of APs required for full coverage. Several factors constitute signal strength quality. Signals in the 2.4 GHz range are susceptible to microwaves found in any office environment. This is somewhat overcome by the frequency hopping incorporated into the IEEE Standard; however, it takes longer to transmit the data. Metal structures tend to reflect the signal very well for coverage into areas not in a direct line of sight. Penetration through metal and wood products tend to absorb the signal very quickly. Concrete absorbs some of the signal as well. We measured a 500-milliwatt (mW) signal to be strong enough to penetrate three 8-in. concrete walls.

Typical APs produce 100 to 500 mW of power. This allows for unlicensed use in most countries. Using 500 mW APs, we can cover approximately 200 ft^2 within an office environment and over 1000 ft with direct line of sight using omni-directional antennas. Antennas provide varying ranges of transmission efficiency rated by the db gains or losses. Typical omni-directional antennas have a db gain of 3. Other antennas range anywhere from a –5 db gain (loss) to a 10-15 db gain. The higher gain antennas are usually directional Yagi type antennas.

6. OBSTACLES

The actual implementation of installing these APs into our facilities proved to be much more difficult than we had planned. Because of tight configuration management at the INEEL, issues such as network technicians not having the correct level of fall protection extended the schedule quite a bit. Most of these APs require mounting to be located at the highest possible location within the facility to provide the best overall coverage. Typical heights range anywhere from 10- to 50-ft high. These heights allow the signal to become more directional to the mobile devices rather than trying to penetrate through material, if located at personnel level. Our radio and communications group had not yet dealt with this new IEEE 802.11 standard and requested technical documentation. After much communication with these folks, they allowed us to continue with the installation and made note of the frequencies and power levels for the given areas. They require these data to comply with standards imposed at the INEEL.

Additional obstacles were that the operators were used to doing business a certain way for many years. They had never been exposed to handling a “handheld computer” before and were very reluctant to embrace the new paradigm. We found that careful one on one attention to the operators with lots of training were not the only factors required to make this new transition to “electronic” handling succeed. The key was to show them how using these new devices enabled them to perform their jobs more efficiently and accurately. Once they realized the time saving in performing an inventory of 1260 containers compared with the “paper” method, they were excited. The old process of inventorying these containers involved generating a report from the database, sorting by location, printing out 60 pages of paper, then marking individual containers as they were identified. Any discrepancies found were noted on paper then entered back at the workstation. With the mobile scanner, inventory time has been reduced by 30%, with much improved accuracy. Additionally, automatically generated reports from the system are now also produced to save time. These reports would take up to a day to produce by hand.

7. SUCCESS

Overcoming the obstacles and given the management support to produce a mobile wireless application have led to improvements in productivity, data accuracy, emergency response, and near real-time tracking. Operators can now scan containers and are ensured the container identification is accurate and that any information received directly from the database can be compared with the real, physical data in a near real-time manner. Inventories are now performed with ease. With more accurate real-time data, auditors can visit our facilities and request any type of data and obtain instant access to accurate information.

8. FUTURE

Wireless and mobile technology is finding its way into many other areas of our business strategies. Warehousing, mail systems, sports, home, and several other industries are just beginning to see the benefits of wireless computing. Development continues on reducing handheld size moving toward palm type devices for even easier data manipulation.

Mobile wireless computing is here to stay. Are you ready to take the plunge?

9. REFERENCES

[1] Symbol Technologies, Inc. – White Paper – "High Data Rate Wireless LAN Technology: Enabling New Applications throughout the Enterprise" - ftp://symstore.longisland.com/Symstore/pdf/HighRate.pdf